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EFFECT OF DRYING METHODS ON THE MILLING QUALITIES OF FUNAABOR- 1 AND FUNAABOR- 2 RICE PADDY

[1]Adesina, B. S., [1]Akinyemi, D.O., [2]Samuel, D.O., [3]Olayanju, T.M.A. and [3]Dairo, O.U.
[1]Department of Agricultural and Bio-Environmental Engineering, Lagos State Polytechnic, Ikorodu, Nigeria.
[2]Department of Chemical Engineering, Lagos State Polytechnic, Ikorodu, Nigeria.
[3]Department of Agricultural Engineering, Federal University of Agriculture, Abeokuta, Nigeria.
Corresponding Author: engrtundeadesina@gmail.com

ABSTRACT

The effect of drying methods on milling quality of parboiled rice paddy was investigated. Hot soaking of the rice paddy was carried out in a thermo- statistically controlled hot water bath between the temperatures of 40 –60°C at soaking time of 30 – 240 min. Tempering was carried out by leaving the soaked samples for 24 hours.

The samples were steamed in an auto-clave for 15 mins. The steamed samples were dried in an Open Shed and Cabinet dryer. The experimental data obtained from the drying methods were fitted to four thin layer drying models: Henderson and Pabis, Logarithmic, Two terms exponential, and Wang and Singh. Goodness of fit was based on highest R^2 and least SSE values. Dried samples of the paddies were milled in a rice miller and the physical qualities of the milled rice were obtained. Open Shed drying method has the highest R^2 and least SSE at 60°C for FUNAABOR- 1 and FUNAABOR -2 as predicted by Logarithmic and Two terms experimental models, while Cabinet drying method has the highest R^2 and least SSE at 50°C for FUNAABOR- 1and at 40°C for FUNAABOR- 2 as predicted by Logarithmic, and Wang and Singh models respectively. High quantities of broken grains were obtained at soaking temperature of 40°C for FUNAABOR- 1and FUNAABOR- 2 in both drying methods. High head rice yield of 71.8 % and 78.50 % were obtained at soaking temperature of 60°C for FUNAABOR- 1and FUNAABOR- 2 respectively in Open Shed drying method. High head rice yield of about
60.6% and 64.3% were obtained at soaking temperature of 60°C for FUNAABOR- 1 and FUNAABOR

-2 respectively in Cabinet drying method. Drying of wet parboiled rice paddy in an Open Shed gave an excellent milling quality.

Key words: FUNAABOR, Parboiled, Paddy, Soaking, Milling, Steaming, Tempering

INTRODUCTION

Rice is the second largest produced cereal in the world, according to Igathinate *et al.* (2008) in tropical countries. Ofada rice is an African rice (*oryza glubberima)*, and a peculiar oryza sativa specie which was first grown in Ofada town, Ogun state, south-west Nigeria. It has since become very popular in the western part of the country. It plays very important role in the diet of many Nigerians and is utilized mostly in households where it is consumed in many forms such as boiled, jollof, fried or "tuwo shinkafa " (local rice pasta).

The paddy rice, irrespective of the variety is usually harvested at high moisture content, between 20 and 25 % wet basis. At this moisture level, micro-organism growth and respiration rate are high. Paddy is parboiled after harvest and this is produced by a process of soaking, pressure steaming and drying prior to milling. This treatment process modifies the starch and permits the retention of much of the natural vitamins and minerals in the kernels (Bhattacharya, 1985). The paddy must be dried to 12 – 14 % moisture content (M.C.) for long term storage (Omar and Yamashita, 1987a). Drying is the reduction of moisture content from the paddy, in order for milling to be easy. Several methods are used for paddy drying. Rice kernel is sensitive to thermal treatment and moisture stress during physical process. Proper drying results in minimum breakages of kernels during milling. Whole rice and whiteness are most important qualities of the rice which gives more commercial value than the broken and partial yellow rice.

Paddy drying is an highly energy consuming process and has significant effect on the milled rice quality such as head rice yield (HRY) and colour (Prahayawakon *et al.*, 2005). So far, there have been various studies to find drying techniques that are energy efficient and that provide high quality rice. Most of them are energy efficient, provide high quality products and recognized multistage drying with tempering in between stages. Saponronmarit (1997) suggested that in order to save energy and obtain a high head rice yield, damp paddy should be dried in fluidized bed dryer (FBD) for the first stage to 18 – 19 % M.C, followed by tempering and then be dried by ambient air ventilation to 12 – 14 % M.C.

Milling comes immediately after parboiling. The main objective of rice milling is to remove the outer layer (Hull) and bran with minimum damage of endosperm. Milling quality of rice is another important criterion used in marketing, grading and classification of rice, as well as treatment such as conditioning and drying. Milling yield vary and depends on several factors such as grain types, varieties, chalkiness, drying and storing

conditions. The milling quality can be determined by two common parameters: Total yield and Head yield. Also another parameter like degree of milling and broken rice are used to estimate milling quality and expressed in percentage.

The remarkable influence of drying condition on the milling quality of parboiled paddy rice cannot be over looked. Hence, there is the need for a detailed study of the influence of drying conditions on the quality of parboiled paddy rice.

MATERIALS AND METHODS

Experimental Material Preparation

Two dual purpose Ofada rice varieties: FUNAABOR-1 and FUNAABOR- 2, a new varietal release by Federal

University of Agriculture, Abeokuta (Showemimo *et al*., 2011) were used. It was sourced from OGADEP (Ogun State Agricultural Development Programme) in Abeokuta, Ogun State, Nigeria.

Moisture Content Determination

The moisture content of the two paddy seeds were carried out using an electrically powered oven which is a more accurate, direct and precise method according to ASAE (1993). The value of the moisture content was computed with the Equation 1.

$M_{cwb} = \frac{W_m}{W} \times 100$

(1) Where: M_{cwb}= Moisture content of wet basis, W_m = weight of water and W = total weight

Hydration Process of Samples

The hot water soaking of the paddies was carried out by putting 100 g of each variety of paddy in a thermo statistically controlled hot water bath. The rice paddy was placed in a perforated container that was kept inside the bath. The temperature of the bath was set at 40 ^{0}C, 50 ^{0}C and 60 ^{0}C using three replicates of each variety. The weight of the paddy was then recorded after 30 minutes intervals for 3 hours.

Tempering and Steaming

Tempering was carried out by leaving the soaked paddies for 24 hours for proper moisture equilibration. Tempering of paddy during drying is very important for obtaining better milling quality. The soaked paddies were then steamed after tempering in an auto-clave by passing steam through the paddies. This was carried out for 15 mins.

Drying

Two methods of drying were used: The Open Shed and the Cabinet drying. The Open Shed drying was carried out by putting samples of each variety on a flat surface tray and leaving it under shed for drying in triplicate. Reading was taken after every 2 hours until it reached the required moisture content. The other sample of the varieties was dried in a cabinet dryer. The samples were put in a flat stainless steel tray and then placed in the dryer in triplicate. Readings were taken at intervals of 10 minutes until the required moisture content was attainted.

Mathematical Modelling of the Drying Process

Midili (2001) reported that drying kinetics can be studied effectively by modeling the drying behavior of food materials. Experiments in drying can be expressed in dimensionless form as Moisture ratio (MR) and can be represented by Equation 2.

$$MR = M - M_e / M_i - M_e \quad (2)$$

Where: M = Moisture content at any time, M_i = Initial moisture content and M_e = Equilibrium moisture content. According to Akgun and Doymaz (2005), Thakor (1999), Torgrul and Pelilivan (2003), the values of M_e may be relatively small compared to M and M_i and as such the equation can be simplified to Equation 3.

$$MR = M/M_i. \quad (3)$$

Moisture ratio from the drying experiment was calculated using Equation 3. The moisture ratio data obtained from the drying experiment were fitted into four thin layer drying models presented in Table 1.

Table 1: Thin Layer drying models considered for drying kinetics

S/N	Model	Model Equation	References
1.	Henderson and Pabis	$MR = ae^{-kt}$	Henderson and Pabis, 1961
2.	Logarithmic	$MR = ae^{-kt} + C$	Yaldiz *et al.*, 2001
3.	Two term exponential	$MR = ae^{-kt} + ce^{-kt}$	Henderson, 1974
4.	Wang and Singh	$MR = 1 + at + bt^2$	Wang and Singh, 1978

Non-linear regression analysis was performed using SIGMA Plot10. The Coefficient of determination (R^2) and Reduced Sum of Squares of Errors (SSE) were used as criteria for goodness of fit of the tested models. The best model describing the thin layer drying kinetics of rice paddy samples was considered as the one with the highest R^2 and least SSE (Ojediran and Raji, 2010, Doymaz *et al.*,2004).

Milling

Dried samples of the two varieties from each method of drying were weighed and prepared for milling. 100 g of each variety was dehusked in a rice miller to obtain the rice from the husk after proper shelling and polishing.

Milling Yield Qualities

In the determination of level of Impurities, 20 g sample of milled rice was weighed. The broken grains were removed. Foreign matter such as dead insects, pieces of wood, dust, stones, and unshelled paddy were then weighed. The level of impurities was calculated using Equation 4.

$$\%\ imp. = \frac{W_i}{20} \times 100 \quad (4)$$

Where: % imp. = percentage of impurity (% imp.) and W_i = Weight of impurity

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For Head rice yield determination, 20 g sample of cleaned milled rice was weighed. The whole rice was manually separated and weighed. Milled rice grains with length greater than three quarter that of complete grains were classed as head rice, remainder consider as broken grains. The head rice yield was calculated using

Equation 5

$$\% \text{ HRY} = \frac{Whr}{20} \times 100 \qquad (5)$$

Where: %HRY =Percentage head rice yield and W_{hr} = Head rice yield

In the determination of broken grains, 20 g of each sample of cleaned milled rice was weighed. The broken grains were selected and weighed to get the percentage of broken grains. The percentage broken grains was calculated using Equation 6.

$$\% \text{ B.G.} = \frac{Wbg}{20} \times 100$$

(6) Where: % B.G. = Percentage broken grain and W_{bg} = Weight of broken grain

For cracked grains determination, 20 g of each sample of cleaned milled rice was weighed. The cracked grains were selected and weighed. The percentage cracked grain was calculated using Equation 7.

$$\% \text{ C.G} = \frac{Wcg}{20} \times 100$$

(7) Where: % C.G = Percentage Cracked grain and W_{cg} = Weight of cracked grain

RESULTS

The initial moisture content of FUNAABOR- 1 and FUNAABOR- 2 were determined to be 16.88 % and 15.48 % respectively on wet basis. The results of goodness of fit of the models considered for the two methods of drying are shown in Tables 2 – 5. Also, the moisture ratios versus drying time curves for the drying methods are shown in Figures 1 – 4. Charts showing the milling qualities of the varieties from the drying methods are shown in Figures 5 - 8.

Table 2: Results of Regression Analysis for Open Shed Drying of FUNAABOR- 1 FUNAABOR-2 Parboiled at Different Soaking Temperatures

Temp. (°C)		40		50		60	
S/N	**Model**	**R^2**	**SSE**	**R^2**	**SSE**	**R^2**	**SSE**
1.	**Henderson & Pabis**	0.9199	0.0093	.8591	.0608	.9105	0.0151
2.	**Logarithmic**	0.9680	.0037	0.9455	.0235	0.9914	0.0014
3.	**Two term exponential**	0.9912	.0030	0.8591	0.0608	0.9914	0.0014
4.	**Wang & Singh**	0.9506	.0058	0.9605	0.0171	0.9899	0.0017

Table 3: Results of Regression Analysis for Open Shed Drying of FUNAABOR- 2 Parboiled at Different Soaking Temperatures

Temp. (°C)		40		50		60	
S/N	**Model**	**R^2**	**SSE**	**R^2**	**SSE**	**R^2**	**SSE**
1.	**Henderson & Pabis**	0.9631	0.0030	0.9360	0.0028	0.8975	0.0053
2.	**Logarithmic**	0.9711	0.0023	0.9897	0.0004	0.9995	.3952E-005
3.	**Two term exponential**	0.9711	0.0023	0.9897	0.0004	0.9995	.3952E-005
4.	**Wang & Singh**						

0.9749	0.0020	0.9942	0.0003	0.9930	0.0004

Table 4: Results of Regression Analysis for Cabinet Drying of FUNAABOR- 1 Parboiled at Different Soaking Temperatures

Temp. (°C)		40		50		60	
S/N	Model	R^2	SSE	R^2	SSE	R^2	SSE
1.	Henderson & Pabis	0.9944	0.0003	0.9986	8.1017E-005	0.9893	0.0008
2.	Logarithmic	0.9949	0.0003	0.9990	5.7653E-005	0.9897	0.0008
3.	Two term exponential	0.9949	0.0003	0.9986	8.1017E-005	0.9893	0.0008
4.	Wang & Singh	0.9955	0.0003	0.9991	5.2185E-055	0.9901	0.0007

Table 5: Results of Regression Analysis for Cabinet Drying of FUNAABOR- 2 Parboiled at Different Soaking Temperatures

Temp.(°C)		40		50		60	
S/N	Model	R^2	SSE	R^2	SSE	R^2	SSE
1.	Henderson & Pabis	.9750	0.0017	0.9918	0.0004	0.9391	0.0020
2.	Logarithmic	.9932	4.71372E-4	0.9965	1.6215E-4	0.9933	0.0002
3.	Two term exponential	.9750	0.0017	0.9918	0.0004	0.9999	2.1620E-6

4.	**Wang & Singh**	.0000	1.2366E-006	0.9966	0.0002	0.9847	0.0005

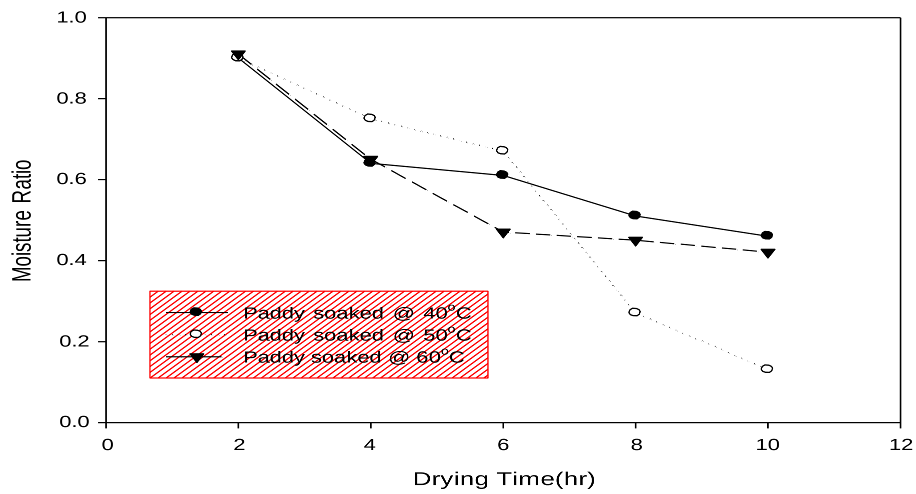

Fig. 1: Moisture Ratio versus Drying Time at Different Soaking Temperature for FUNAABOR- 1 in Open Shed Drying

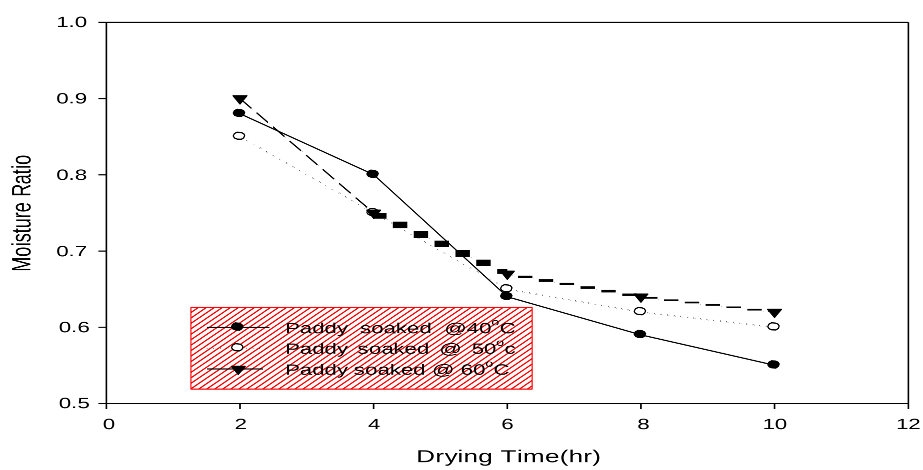

Fig. 2: Moisture Ratio versus Drying Time at Different Soaking Temperature for FUNAABOR- 2 in Open Shed Drying

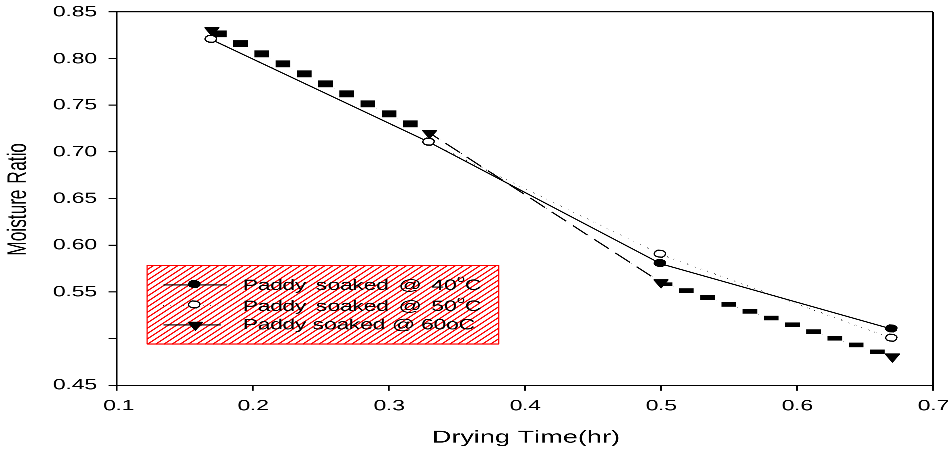

Fig. 3: Moisture Ratio versus Drying Time at Different Soaking Temperature for FUNAABOR- 1 in Cabinet Drying

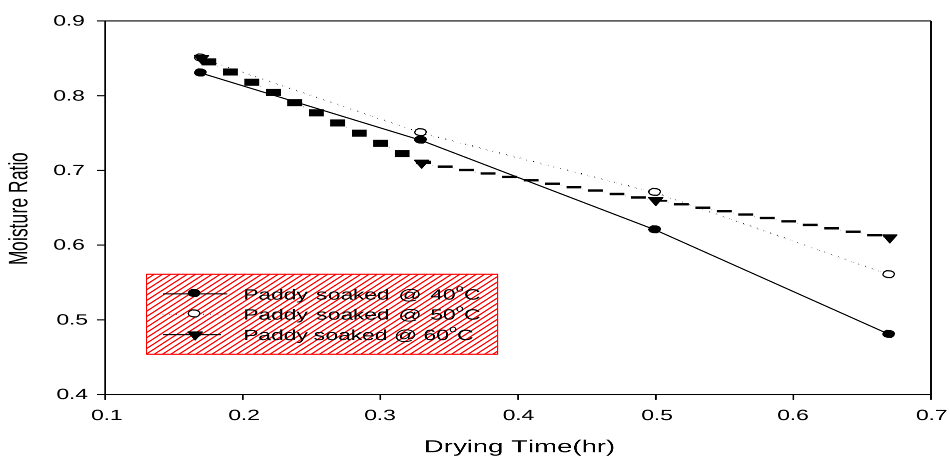

Fig. 4: Moisture Ratio versus Drying Time at Different Soaking Temperature for

FUNAABOR- 2 in Cabinet Drying

Table 6: Physical Milling Qualities Parameters at different Parboiling Temperatures for Open Shed Drying

Variety	Parboiled Temp.(^oC)	%HRY	%BG	%CG	%IMP
	40	60.5	20	10.5	11.4
FUNAABOR-1	50	67.2	12.2	9.3	8.2
	60	71.8	7.2	6.5	5.5
	40	61.5	18.0	9.6	10.7
FUNAABOR-2	50	65.8	10.3	7.8	7.3
	60	78.5	6.5	4.5	3.5

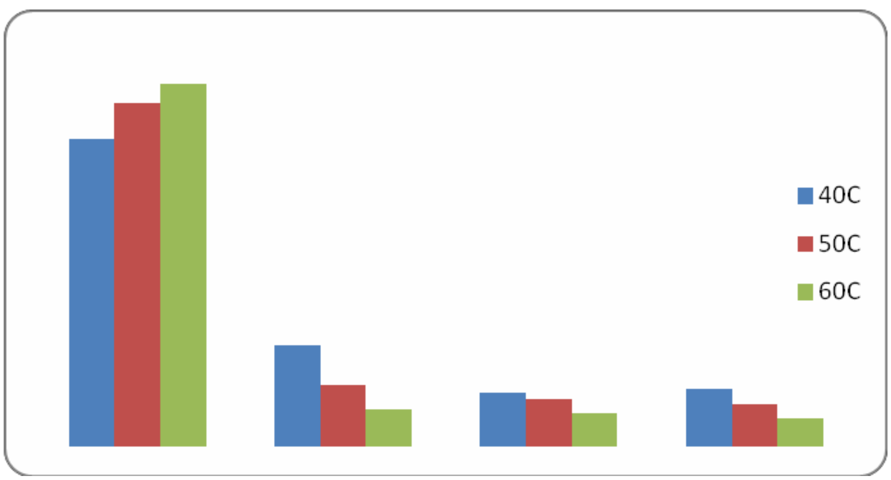

Fig.5: Milling Qualities of FUNAABOR- 1 at different Soaking Temperature for Open Shed drying

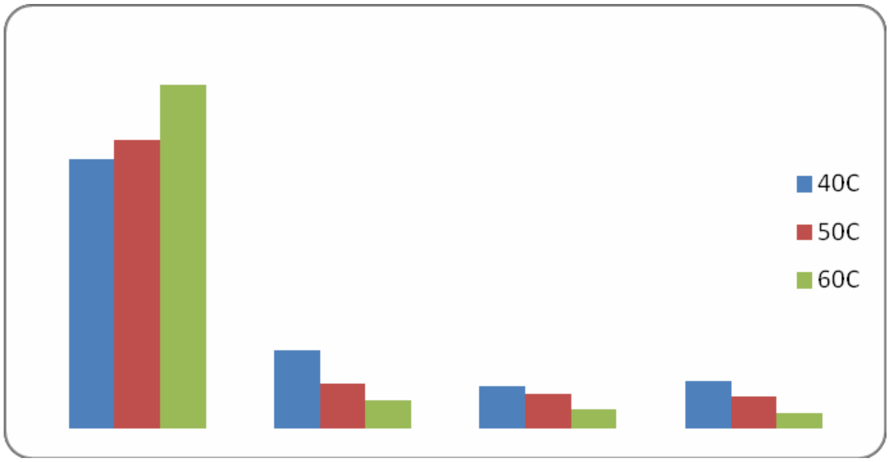

Fig.6: Milling Qualities FUNAABOR- 2 at different Soaking Temperature for Open Shed drying

Table 2: Physical Milling Qualities Parameters at different Parboiling Temperatures for Cabinet Drying

Variety	Parboiled Temp.(^oC)	%HRY	%BG	%CG	%IMP
	40	55.5	23.5	28.3	15.5
FUNAABOR-1	50	58.4	20.5	26.5	12.5
	60	60.6	16.2	25.0	10.4
	40	58.3	21.3	29.5	14.0
FUNAABOR-2	50	60.4	18.6	25.0	11.5
	60	64.3	15.5	17.3	8.5

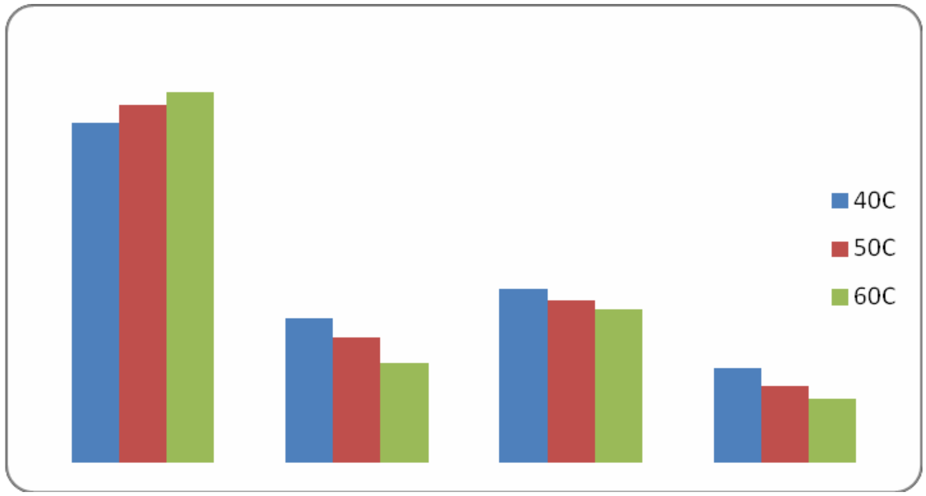

Fig.7: Milling Qualities of FUNAABOR- 1 at different Soaking Temperature for Cabinet Drying

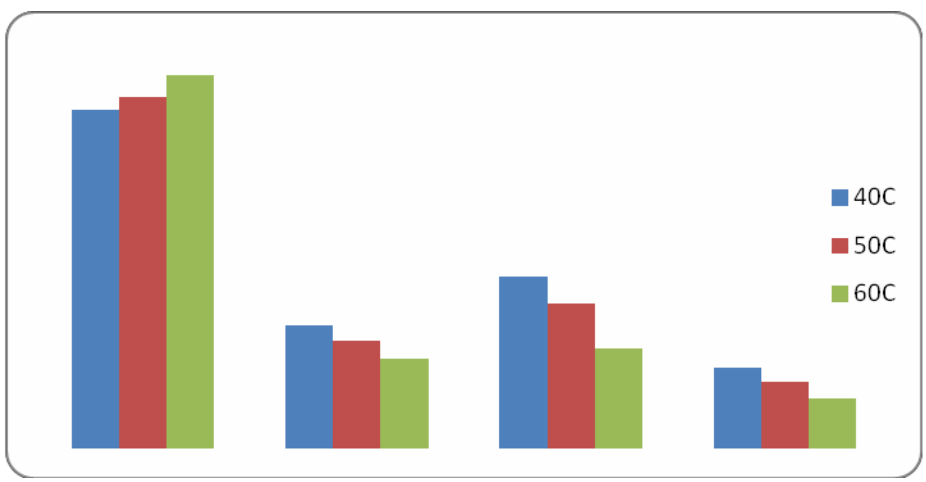

Fig.8: Milling Qualities of FUNAABOR- 2 at different Soaking Temperature for cabinet Drying

DISCUSSION

The study showed that there was decrease in moisture content and ratio with increased drying time at the soaking temperature range studied as shown in Figures 1- 4. The drying behaviour of the rice paddy is represented by the fit of the models to the data generated using Open Shed and Cabinet Drying methods. Logarithmic and Two terms experimental models gave the highest R^2 values of 0.9914 and 0.9995 and least

SSE values of 0.0014 and 2.3952 E-005 at 60 ^oC for FUNAABOR- 1 and FUNAABOR-2 respectively in open shed drying as shown in Tables 1 and 2. Logarithmic model has the highest R^2 and least SSE values of

0.9990 and 5.7653E-005 at 50 ^oC for FUNAABOR- 1, while Wang and Singh model gave the highest R^2 and least SSE values of 1.0000 and 1.2366 E-006 at 40 ^oC for FUNAABOR- 2 in cabinet drying as presented in Tables 3 and 4.

Akinjide *et al*. (2014) reported that comparing the best regression values from drying methods can be used as a criterion for understanding and predicting the best method by which a food material can be dried. The best model describing the thin layer drying characteristics of food materials according to Ozdemir and Davies (1999) and Ertekin and Yaldiz (2004), was considered as the one with highest R^2 and least SSE. From this present

study, open shed drying has highest R^2 and least SSE at 60^oC for FUNAABOR- 1 and FUNAABOR- 2 as

predicted by Logarithmic and Two terms experimental models, while Cabinet Drying has the highest R^2 and least SSE at 50 ^oC for FUNAABOR-1 and at 40 ^oC for FUNAABOR- 2 as predicted by Logarithmic and Wang and Singh models respectively.

Degree of milling is a measure of the extent to which the bran layers and germ have been removed. It was observed that after polishing, (which involves the removal of the aleurone layer), FUNAABOR-2 gave the characteristic white colour of fully parboiled rice, while the FUNAABOR-1 variety gave a mixture of both white and brown colours, showing that all the aleurone layer has not been completely removed. This is similar to result obtained by Adesina (2014) when Ofada rice was milled with mixtures of both white and brown colours. This variation in colour for FUNAABOR-1 and FUNAABOR-2 was also reported by showemimo *et al*. (2011).

High quantities of broken grains were recorded at soaking temperatures of 40 ^oC for FUNAABOR-1and FUNAABOR- 2 in both Open Shed and Cabinet Drying (Figures 1 - 4). This suggests that proper parboiling has not been done at this temperature. High head rice yield of about 71.8 % and 78.50 % were obtained at soaking temperature of 60 ^oC for FUNAABOR- 1and FUNAABOR- 2 respectively in Open Shed drying (Table 1). This is within the recommended milling yields of between 64 – 75 %, according to Ojha and Michael (2006). However, FUNAABOR- 2 gave higher head rice yield. Similarly, High head rice yield of about 60.6 % and

64.3 % were obtained at soaking temperature of 60 ^oC for FUNAABOR- 1and FUNAABOR- 2 respectively in

Cabinet Drying (Table 2). The value obtained for FUNAABOR- 2 can be considered to be within the recommended milling yields of 64 – 75 % as reported by Ojha and Michael (2006). But the value obtained for FUNAABOR- 1 is not within the range. Generally, paddy dried in Open Shed gave the highest % milling yield. This is in agreement with the report of Juliano (1985) and the work of Adesina (2014).

CONCLUSION

From this work, Open Shed drying has highest R^2 and least SSE at 60 ^oC for FUNAABOR- 1 and FUNAABOR- 2 as predicted by Logarithmic and Two terms experimental models, while Cabinet Drying has the highest R^2 and least SSE at 50 ^oC for FUNAABOR- 1and at 40 ^oC for FUNAABOR- 2 as predicted by Logarithmic, and Wang and Singh models respectively. High quantities of broken grains were obtained at soaking temperature of 40 ^oC for FUNAABOR- 1and FUNAABOR- 2 in both Drying methods. Higher head rice yields were obtained at soaking temperature of 60 ^oC for FUNAABOR- 1and FUNAABOR- 2 in Open Shed drying method than in Cabinet drying method. This present study has shown that drying of wet parboiled rice paddy in an Open Shed gave an excellent milling quality.

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